Editorial Note

We have several reports on previous meetings from this very active group which I hope will give a flavour of the breadth of subjects covered. Why not consider attending a meeting next time if the ones reported here look interesting? There are still spaces available at our Members' Day on 10th May at the time of going to press. Travel bursaries are almost always available for those in need. This Newsletter includes the exciting innovation of photographs of (most of) your committee. Don't forget to send your meeting announcements to me for inclusion in the next edition (autumn 2006).

Karen Aplin

Notices

15th Annual General Meeting of the Environmental Physics Group

1.40pm, Wednesday 10th May 2006
76 Portland Place, London

AGENDA

(1) Welcome

(2) Chairman's Report.

(3) Secretary's Report

(4) Treasurer's Report.

(5) Committee Elections

(6) AOB

Essay Competition Results

The inaugural EPG essay competition is nearing its conclusion and it is with great pleasure that I can announce the results on behalf of the judging panel.

The first prize, of £500, has been won by Sally Brown, of the University of Southampton, for her essay on coastal erosion. Due to the high standard of entries, we also decided to reward two further authors. A second prize of £200 has been awarded to Emma Turner of Imperial College, for her entry on ice cores. Jennifer McClure of Liverpool University has been awarded a third prize of £100 for her essay on the northern lights. Publishing outlets are now been sought for the essays.

The prizes will be presented at the EPG Members' Day meeting, which will be held on Wednesday 10th May 2006 at the Institute of Physics headquarters in London. The winners will also be presenting a synopsis of their essays. (Further details on Members' Day have been sent to members separately).

The judging panel included EPG committee members Peter Hodgson, Derek Rose and Edward Youngs and the Acting Editor of Physics World, Matin Durrani. The panel were very impressed with the standard of entries and all the authors are thanked and congratulated on their contribution.

The EPG committee intend to run the competition on an annual basis – look out for announcements later this year.

Peter Hodgson

Forthcoming Events

British Soil Water Physics Group Meeting

ROOTS & THE SOIL PHYSICAL ENVIRONMENT

Wednesday June 7th 2006, 12.30-1700

The University of Nottingham (University Park Campus)

A recent Association of Applied Biologists conference - 'Roots and the Soil Environment' - focused on the key issues and strategies relevant for optimizing root systems using genetic, crop and soil management approaches. One area that was highlighted in particular was the effect of the soil physical environment on root development. This meeting will focus specifically on aspects of soil physical properties and root interactions. Contributions in all related areas are encouraged and might include issues relating to soil compaction / strength, aeration, hydraulic properties of the rhizosphere, soil structure, in situ measurements and microbial activity.

We aim to have six speakers to cover the subject matter followed by a group discussion. There will be invited contributions from Rothamsted Research, Institute of Grassland and Environmental Research and the University of Plymouth. In addition, we invite offered papers from active researchers in this field. Please contact

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There is no charge for this event.

Reports from Previous Meetings

'Life at the Boundaries : The Physics of Survival and Endurance'
Wednesday 2 March 2005, Geological Society of London

Introduction

The aim of this meeting was to explore the interdisciplinary nature of survival and survival mechanisms, and how these are underpinned by Environmental Physics, especially where Physics interfaces with Biology. We wanted students to realize that the theme of the meeting is a very exciting and important branch of Science, with ramifications for the well-being of the planet and its living species. In excess of 85 people attended. These included undergraduates, postgraduates and lecturers from Physics, Biology, Geography, Sport and the Medical and Military Sciences.

The meeting was ably chaired by Dr D Tunstall-Pedoe who is an expert on cardian research and sports medicine. His many achievements include pioneering work on the use of Doppler ultrasound as a diagnostic technique in cardiology in Britain. Spectral Doppler ultrasound is now used by most cardiology departments worldwide as part of routine ultrasound cardiac evaluation. He has also been medical director of the London Marathon for the past 25 years and has written a book, "Marathon Medicine" (RSM press, 2001).

An abstract for each of the talks is appended below.

Mountains, high altitude medicine and endurance Andrew Sutherland (Nuffield Department of Surgery, Oxford)

My talk will centre on survival at high altitude. I will first discuss physiological adaptations to altitude, specifically how the body compensates for marked reductions in the partial pressure of oxygen. I will concentrate on the acute and long-term adaptations that our bodies make including changes in heart rate, ventilation, and haemoglobin concentration. I will then discuss the high altitude medical conditions, Acute Mountain Sickness (AMS), High Altitude Pulmonary Edema (HACE), and High Altitude Cerebral Edema (HACE). I will discuss the various theories for the underlying pathophysiology of these conditions as well discussing their treatment. I will focus on how changes in individuals' environment and microenvironment can aid survival at high altitude. I will also illustrate how our understanding of medicine in these extreme environments can advance the understating and treatment of a number of common medical problems. Finally I will discuss the importance of a multidisciplinary approach for this type of research and the requirement to think 'outside the box'.

Thermodynamics and Bioenergetics: The Implications for Survival John M. Wrigglesworth (formerly of King's College London).

Thermodynamics provides a useful measure of the limits of energy utilisation by living organisms (bioenergetics). The First Law of thermodynamics deals with the conservation of energy and can be used to measure the balance of energy input (food) with energy output (heat and work). I will use the example of non-shivering thermogenesis in mammals to illustrate the implications of the First Law for weight gain and loss and for adaptation to cold stress. The Second Law of thermodynamics is concerned with the distribution of energy and the way in which different forms of energy can be used to do work. One conclusion of the Second Law is that under constant temperature (isothermal) conditions, heat cannot be converted to work. Since living systems are isothermal, they have to utilise other forms of energy (chemical, electrical, sunlight etc) to carry out the necessary functions for life. I will use the example of exercise to illustrate the implications of the Second Law in placing limits on the ability of humans to react to various stressful situations.

How Physics helps microbes survive in extreme environments Charles Cockell (Planetary and Space Sciences Research Institute, Open University)

Some environments on Earth are sufficiently extreme that it would appear, at least at the macro-scale, that they are inimical to life. Such places include hot deserts, the cold wind-swept freezing deserts of the polar regions, and high altitude locations. However, at the scale of millimetres or even microns, microhabitats, particularly within rocks, provide places where microbial life can thrive, even in these harsh environments. The much more clement conditions to be found in microhabitats are a result if quite simple physical processes. For example, rocks scatter and absorb UV radiation, providing protection from this part of the electromagnetic spectrum, which is known to cause damage to the genetic material,. DNA. The absorption of heat by rocks provides a more thermally favourable environment compared to the surface of the rocks, providing a clement habitat foe endoliths – organisms that live within rocks. Rocks can only also trap moisture by virtue of capillary action and the leaching of water into fractures within the rock material. Taken together these physical processes can make enormous differences to environmental conditions over scales of just a few mm. Such processes might speculatively be important for the origin and evolution of life elsewhere as they are not unique to Earth, but rather the result of simple, universal principles. By examining these microhabitats and the microbes that live in them, we get a wonderful insight into how Physics can help life thrive in places uncomfortable to you and I.

Survival and extinction during crises in Earth history Michael Benton, (Department of Earth Sciences, University of Bristol)

There have been many mass extinctions during the history of life, events during which 50% or more of species died out during a relatively short time. Palaeontologists generally identify six (or seven) such events:

- Late Precambrian event (600 million years, Myr, ago)
- Late Ordovician (450 Myr ago)
- Late Devonian (375 Myr ago)
- End-Permian (250 Myr ago)
- End-Triassic (200 Myr ago)
- End-Cretaceous (the 'KT event', 65 Myr ago)
- Present-day

Studies of individual mass extinctions show a variety of patterns, with some apparently taking place extremely rapidly, and others over longer periods of time, some restricted geographically, and others worldwide in extent. Causes are much debated: impact has been most touted publicly, but most of these seven were probably the result of climate change, sometimes induced by massive volcanism, sometimes by major glaciation. Uniquely for the KT event there is abundant evidence of one or more major impacts on the Earth, and these must relate to the extinctions. Evidence for impacts of this sort in association with other major mass extinction events is limited, and it is not clear that there was a single driving mechanism that caused all, or even most, mass extinctions following a periodic cycle.

There is limited evidence for ecologic selectivity during mass extinction times: the only genera at risk are those with restricted geographic ranges. In fact it is a defining feature of mass extinctions that they should witness extinctions across a broad range of organisms ecologically, in terms of size, habitat, geographic location, phylogenetic position, and so on. This is a somewhat counter-intuitive proposition, since most biologists might predict that large animals, top carnivores, taxa with narrow ecologic tolerances, and endemic taxa would be highly extinction-prone. Numerous studies by palaeontologists, however, have turned up relatively little evidence for selectivity during mass extinctions. The KT event certainly killed the dinosaurs and some other large reptiles, but a full survey shows that a larger number of microscopic planktonic species died out.

The only evidence of selectivity during mass extinctions has been against species with limited geographic ranges. David Jablonski of the University of Chicago surveyed all bivalve and mollusc species and genera of the latest Cretaceous and earliest Tertiary in North America and in Europe, and he found that genera which were geographically restricted were selectively killed off, when compared to taxa with wider species distributions. Defence against extinction would seem to be a species within a genus that occupies as broad a geographic area as possible. Body size and niche seem to be unimportant.

Geographic realm might also be thought to be significant in selectivity during mass extinction events. It has long been suspected that tropical taxa are more extinction-prone than are those with more polar distributions. This idea was based on the observation that some mass extinction events are associated with an episode of cooling. During such a cooling phase, temperate-belt taxa could migrate towards the tropics, tracking their ideal temperature regimes, but the tropical taxa have nowhere to go, and they are squeezed out. Another study by David Raup and David Jablonski, however, has shown no evidence for latitudinal differences in extinction intensities of bivalves during the KT event.

Humans in various thermal environments Professor Ken Parsons (Human Thermal Environments Laboratory, Loughborough University)

Human responses to hot, moderate and cold environments can be predicted from the laws of physics. These include heat stress, cold stress, thermal comfort, human performance and survival. Predictions can also be made of burns on skin contact with hot surfaces and frostbite to local areas of the body. Calculations of heat exchange by conduction, convection, radiation and evaporation between any thermal environment and a person can lead to an estimate of the total heat load on that person and hence the requirements of the thermo-regulation system to respond. Equations of heat exchange for the human body have been determined by research and are incorporated into this 'rational' approach to assessing thermal environments.

This presentation will demonstrate how the laws of physics have been used to provide a unified method for assessing thermal comfort as well as survival in heat and cold. Knowledge and methods are sufficiently mature for this approach to provide an analysis of any thermal environment and make a prediction of practical value. Risk of injury, survival times and death can be predicted with sufficient accuracy to inform a management system designed to ensure safety when people are exposed to extreme conditions.

Peter Hughes

Investigations into Soil Architecture

76 Portland Place, London, Wednesday 2 November 2005

This half-day meeting, held jointly with the British Soil Water Physics Group, was organised by Edward Youngs and Derek Rose and attracted 20 participants. In contrast to the many meetings that have discussed the modelling of porous structures, this meeting focused on recent advances in visualising, measuring and analysing the internal structure of porous materials, particularly the pore space, by non-invasive techniques.

The opening paper, Life and Architecture of Soil, by Professor Iain Young of the University of Abertay, introduced soil architecture from the point of view of the functioning of small organisms such as bacteria, fungi and nematodes, in particular their need for resources. He gave a telling example of a handful of soil containing more individual organisms than the total numbers of humans that have even lived; yet, due to the very large internal surface area of soil, less than 1 part in 10 million of the total surface area is covered in microbes and, as the soil dries, this proportion falls by several orders of magnitude for respiring micro-organisms. He showed how Computer-aided Tomography could map the internal architecture of soil and how this information, plus a knowledge of the energy status of the soil water (measured by the moisture-release curve), could explain the functioning of small organisms in the soil. Dr Sacha Mooney of the University of Nottingham then spoke about the benefits of quantifying soil pore structures using X-ray Computed Tomography (CT) and image analysis. CT is a non-destructive imaging technique in which a large number of transmission measurements of an X-ray beam are used to reconstruct an image of the cross-section of a scanned object. Using digital image processing, it is possible to obtain 3-D visualisations from density-attenuation maps derived from 2-D scans. He described current work at Nottingham using these techniques at varying size scales to quantify the pore structure of soils with respect to several current agro-environmental issues including soil structural stability, preferential flow pathways and the strength of anchorage of plant roots.

Dr Edward Randall of Queen Mary College, University of London, then gave a detailed exposition of Stray Field (STRAFI) Nuclear Magnetic Resonance (NMR) and how it could be used to measure, non-destructively, the distribution of water in soil, in particular, the size-distribution of water filled pores. STRAFI-NMR is capable of imaging the protons of water in soil without the extensive distortions of conventional MRI which are due to variations in magnetic susceptibility in the soil matrix. As with all imaging techniques, it requires much care to obtain reliable results, but represents a considerable advance on those found from conventional NMR. The last paper, given by Dr Peter Matthews of the University of Plymouth, compared simulated void structure of sandstones obtained by NMR and from conventional thin sections. The techniques were complex, for the thin-section data were mathematically microtomed into 100 slices from simulations using the Pore-Cor network model of mercury-intrusion curves of five sandstones of widely differing structure. He concluded that calibrating NMR relaxation times using

the commonly used capillary-bundle approximation of pore structure is dangerous. The meeting closed with a lively discussion that addressed questions of calibration, the representative nature of samples, the ability to generalise results from the large quantities of data resulting from these techniques, and how realistic is it to rely on a snapshot in time of a property of soil, its architecture, that is always changing.

Derek Rose

History of Air Pollution

Dirac House, Bristol, Wednesday 30th November 2005

The afternoon meeting of the IoP entitled the *History of Air Pollution* was held on 30 November 2005 in the new venue of Dirac House, Bristol. The awareness of air quality was introduced as being a long-standing and interdisciplinary concern, with applications from public health to climate change.

The afternoon presentations began with a fascinating talk by Prof. Peter Brimblecombe (University of East Anglia) who reminded us that pollution is not just a modern concern, with ancient civilizations also recognising the need to consider and protect the environment they lived in. This talk highlighted policies on air pollution adopted by the Sumerians and Babylonians, where smoke was recognised as being detrimental to the settlements, and the general association by ancient religions between cleanliness and closeness to God. The practical steps made by the ancient Greeks were also discussed, such as evidence from Aristotle's Athens that rubbish was deposited outside the city walls to avoid the associated smell and spread of disease. Polluting industries such as glassmakers were confined to Roman suburbs during the era of Sextus Julius Frontinus around the first century A.D, with his dedication to the water supply of Rome marking the beginning of professional environmental administration and recognition of health and air quality being on the minds of settlement planners of ancient civilisations across the world.

A review of more recent air pollution concern was presented by Prof. Ian Colbeck (University of Essex). This talk concentrated on analysis of related press articles about smoke and fog in nineteenth century London, with a variety of interesting and often amusing accounts and cartoons of the smog from the press. Sourcing from *The Times* and the weekly magazine *Punch*, concerns and opinions of the general public towards the London Smog and the current government policy on air pollution were portrayed, included the more positive side such as a sense of adventure the smog provided, and even a somewhat implausible excuse to be found "lost" in a gin shop! Attitudes of the industries responsible for the air pollution were shown to be varied, from understandable concern to optimistic suggestions that the smoke they produced was actually good for one's health!

Continuing the theme of a more qualitative account of historical air pollution, the use of Monet's London Series in the assessment of air quality was put forward by Dr. John Thornes (University of Birmingham). In this eye-opening

presentation the importance of visual literacy in science was identified, with landscape art holding a unique account of environmental history. The work of Monet and Constable were selected for their detailed portrayal of the sky, with evidence that the meteorological conditions depicted were often in good agreement with measurements of the time. The London Smog featured strongly in the paintings of Monet and even provided a proxy to air quality, giving visibility estimates of a similar value to estimates observed during a coincident survey on the smog by the Meteorological Office.

Dr. Karen Aplin (Rutherford Appleton Laboratory) presented work on atmospheric electrical retrievals of smoke, conducted in collaboration with Dr. Giles Harrison (University of Reading). In a talk that provided the only equations of the afternoon, the theory that related atmospheric electrical measurements to aerosol concentrations was discussed. Atmospheric electrical parameters such as total air conductivity, potential gradient (negative of electric field) and the vertical conduction current density were measured at Kew, London, between 1909 and 1979. This predates aerosol concentration measurements, so a quantitative proxy provided a valuable account of historical air quality in outer London. Both diurnal and inter-annual characteristics were discussed, including a novel dataset of potential gradient at the top of the Eiffel Tower that provided an insight into Parisian air quality during the late nineteenth century.

The afternoon concluded with a presentation by Dr. Stephen Mosley (Leeds Metropolitan University) on the standardization of air pollution measurement and monitoring between 1912 and 1966. The increasing competence and involvement of a wide variety of organisations concerned with air quality monitoring was highlighted along with the many issues, both scientific and political, that were overcome during this period. In particular, the negative portrayal of the most polluted cities by the media lead to a reluctance of cooperation by some local authorities, a problem at least partially solved by subsequent anonymity in publicised national reviews. Strategies to limit the extent of local deviations in data quality were discussed, such as the more centralised control of air quality monitoring over local authorities, with the advancement of UK air quality measuring and monitoring shown to be a good example of successful cooperation between industry, local and national government groups.

Overall, the series of presentations provided the audience with a refreshing look at alternative and complimentary sources of historical air quality data. Many thanks to all the speakers and to Karen Aplin for organising what proved to be a successful and thought-provoking afternoon.

Alec Bennett, University of Reading

Environmental Physics News

Geophysics Education in the UK

One consequence of the great advances in solid earth geophysics in the last few decades has been the emergence of about a dozen UK universities with excellent first degrees in geophysics. These combine classical geology and physics with mathematics and computing in stimulating ways. They provide the basic skills needed in many vital industries and establishments active in research, education, the public sector, archaeology and environmental monitoring. However, despite the buoyant demand for graduates, the number of students entering universities to read geophysics degrees has fallen by over 50% in the last two decades, against the national trend of increasing total number of students entering tertiary education. This is only partly explained by falls in the number of students doing A-levels in the subjects normally required for entry (20% fall for mathematics and 40% fall for physics). In the same period, the number of geophysics MSc courses in Earth science departments fell from five to one. This continuing decline worries employers as well as universities and learned societies and is the subject of an on-going review by the British Geophysical Association (BGA), through sponsorship from the Royal Astronomical Society (RAS) and the Geological Society of London (GSL). A full report will be published shortly.

The current and past students surveyed (40% female) were generally of excellent quality with an average A-level grade of B in both physics and mathematics. Most embarked on the subject because of scientific curiosity without a specific career in mind. Without exception, they found their courses highly educative, lively and informative and thoroughly enjoyed their time at university. The oil industry was the most common employer followed by IT, private companies, the public sector, the environment, mining, teaching and research. The students' responses clearly indicate that the shortage of applicants is due to lack of awareness in schools. Those who chose geophysics generally found the courses in their search for something exciting to do, while their colleagues chose other courses because of the lack of information on geophysics and the perceived difficulty of physics and mathematics.

The oil related companies that responded varied in size from those employing a few geophysics graduates to those with hundreds. The big multinationals recruit worldwide so it is important to continue producing high quality graduates in the UK, or British involvement in the industry will decline. There are serious concerns in the industry about the future supply of good geophysics graduates from the UK.

Employers in the non-oil sector include those in environmental, engineering, water, mining, and archaeological applications. In such industries multi-skilled people are required by small companies. Geophysics is the ideal university education as it is broadly based, but even geophysics graduates need several years' experience to gain the required skill. The skill base is very fragile at

present and there is an urgent need for more research and development to underpin this area of the science, which is growing in importance.

The public sector includes the British Geological Survey, which has over 500 geoscientists in a range of thematic programmes and requires geophysicists for both on- and off-shore investigations. The Ministry of Defence supports a prestigious research centre for seismic detection of underground nuclear explosions, vital for monitoring the international development of nuclear weapons. It also has anxieties about the future supply of good graduates.

There is a great danger that the University provision will continue to decline in response to the fall in applications. It is already compromised and diversified to cope with effects of the research assessment exercise (RAE), admissions numbers, a halving funding per university student, and the declining skills base of the intake. The decline must be arrested with geophysics promoted in schools nationally to promote a recovery.

An illustration of what can be done is given by enthusiastic physics teachers in two schools, which now operate seismographs with the aid of grants from the Royal Society and have linked up with the highly successful 'Incorporated Research Institutes for Seismology' schools' network in the US. Their recordings of the 2004 Boxing Day Sumatran earthquake responsible for the tsunami and the October 2005 earthquake in Pakistan were widely reported in the press. A natural consequence is the development of interest in the physics of waves. Many other basic concepts in classical physics including gravity, magnetism, electricity, and radioactivity can be introduced using the Earth as a laboratory. There is a need for workshops to educate teachers on the merits of using Earth examples to illustrate basic physics concepts. Geophysics is an admirable way of enthusing pupils to continue with physical science and mathematics to university level and an excellent introduction to a wide-range of degree courses. There is an urgent need for the learned and professional societies concerned with the earth and physical sciences to collaborate with each other as well as universities and schools to promote geophysics as a broad educational subject and to meet the growing demand for well-qualified graduates.

Aftab Khan, University of Leicester
Peter Maguire, President, British Geophysical Association (BGA*) until March 2006
Christine Thomas, Education Secretary, BGA

*The BGA (http://www.geophysics.org.uk) is a Joint Association of the Royal Astronomical Society and the Geological Society of London, and represents UK geophysics and geophysicists. We would welcome your comments. Please contact Sheila Peacock at s.peacock@blacknest.gov.uk or 01189 827260.

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